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RESEARCH INVESTIGATION OF p-i-n ELECTRON JUNCTION DETECTORS

Interim Engineering Report No. 1
11 February 1963 through 11 May 1963

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INTERIM ENGINEERING REPORT NO. 1

RESEARCH INVESTIGATION OF p-i-n ELECTRON JUNCTION DETECTORS

This report covers the period 11 February 1963 through 11 May 1963

HUGHES RESEARCH LABORATORIES
a division of hughes aircraft company
Malibu, California

NAVY DEPARTMENT BUREAU OF SHIPS ELECTRONICS DIVISIONS

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ABSTRACT

For the purposes of studying the response of silicon, lithium-drifted p-i-n junction detectors to electron sources, an extrapolation chamber and its associated circuitry have been set up and put in working condition. The measurement of surface dose rates for carefully specified geometries has begun, using a liquid thallium-204 thick source.

PART I

PURPOSE

The purpose of this contract is to

1. Conduct a research investigation of the absolute sensitivity of p-i-n junction radiation detectors for various ionizing radiations.

2. Conduct an analysis of the extent to which p-i-n junction radiation detectors can satisfy Naval requirements for radiation detectors.

GENERAL FACTUAL DATA

Identification of Investigators

A list of personnel connected with this study and a summary of man-hours expended will be supplied in a supplementary letter.

Measurement Procedures

A polystyrene surface extrapolation chamber of the Failla design[1] was used for measurement of surface dose rates. The depth of the polystyrene block was approximately 2.5 cm, and its idameter was 15 cm. The collecting electrode diameter, defined by a very fine scratch in the graphite film, with which the polystyrene surface is coated, was 1.0815 cm. The front electrode was a 0.00025-in. aluminized mylar film, whose distance from the polystyrene surface was measured for each setting using the capacitance bridge circuit of Rossi and Ellis,[2] which permits the measurement to be made with the source of ionizing radiation present. The other components of this bridge consisted of a (1.0 ± 0.1 percent) μμf General Radio Standard Air Capacitor, Type 1403-K, a General Radio Decade Resistance Box, Type 602-M, a Leeds & Northrup Decade Resistance Box, Type 4776, and a Cary Vibrating Reed Electrometer, Model 31, used as a null indicating device.

This same electrometer is used as a null indicating instrument in the circuit used for ionization current measurement. This circuit is the modified Townsend balance circuit of Pruitt and Domen[3]. The same air capacitor was also used, while a Sensitive

Research Instruments Universal "88" Polyranger was used to monitor the compensating voltage. The internal capacitance in the head of the electrometer was calibrated by the method described by Pruitt and Domen,[3] using a Boonton Electronics Standard Capacitor, Model CS-10.

At the present, a number of thin-entrance-window p-i-n junction detectors of various sizes are being fabricated for use in this study.

DETAIL FACTUAL DATA

The major activity of this reporting period has been setting up the extrapolation chamber circuitry and calibrating certain circuit components. The dose rate measurements made with the extrapolation chamber, which is the only absolute method for measuring dose rates resulting from sources which emit β-rays, will be used as a standard by which the β dose rate measuring capabilities of the p-i-n junction detectors will be judged.

Initial dose rate measurements, made using a thick thallium-204 source (1.5 mc/ml) with a 100 cm^2 area, confirm that the equipment is functioning properly. Measurements, reproducible to better than 1 percent, were made with this equipment at currents as low as 10^{-14} A.

Conclusion

The equipment herein described has been confirmed to be functioning properly so that absolute dose measurements may be made by this method.

PART II

PROGRAM FOR NEXT INTERVAL

The extrapolation chamber measurements will be continued, using dishes of various areas and also using various β- and γ-ray emitting sources.

A number of p-i-n junction detectors of various sizes, now being fabricated, will be employed as current generators under the conditions of geometry and dose rate standardized by the extrapolation chamber measurements. The correlation between the resulting open-circuit voltage and the surface dose rate will be studied. These detectors will be of the thin-window type, as previous experiments indicate that elimination of the thick dead layer should result in a more nearly linear correlation between surface dose rate and open-circuit voltage. These same thin-window detectors will be used at lower dose rates in the pulse-counting mode and using thin dried sources.

REFERENCES

1. G. Failla, The Measurement of Tissue Dose in Terms of the Same Unit for All Ionizing Radiations, Radiology 29, 202 (1937).

2. H. H. Rossi and R. H. Ellis, Jr., Dosimetry of Thin Polonium Sources, Nucleonics 7, 21 (1950).

3. J. S. Pruitt and S. R. Domen, Determination of Total X-Ray Beam Energy with a Calibrated Ionization Chamber, National Bureau of Standards Monograph 48 (U. S. Government Printing Office, Washington, D. C., 1962), pp. 4-5.